BOSTES | BOARD OF STUDIES TEACHING & EDUCATIONAL STANDARDS NSW

# 2014 HSC Physics
# Marking Guidelines

## Section I, Part A

### Multiple-choice Answer Key

| Question | Answer |
|---|---|
| 1 | D |
| 2 | B |
| 3 | D |
| 4 | D |
| 5 | B |
| 6 | A |
| 7 | B |
| 8 | D |
| 9 | A |
| 10 | C |
| 11 | B |
| 12 | C |
| 13 | C |
| 14 | B |
| 15 | A |
| 16 | A |
| 17 | B |
| 18 | D |
| 19 | A |
| 20 | D |

## Section I, Part B

### Question 21

| Criteria | Marks |
|---|---|
| • Identifies THREE limitations | 3 |
| • Identifies TWO limitations | 2 |
| • Identifies ONE limitation | 1 |

***Sample answer:***

- The cost of cooling is high
- New infrastructure is required for transmission
- Superconductors only transmit DC

### Question 22

| Criteria | Marks |
|---|---|
| • Correctly relates the effects of the re-entry angle to the safety of astronauts | 3 |
| • Shows some understanding of how the re-entry angle affects the safety of astronauts | 2 |
| • Shows a basic understanding of the re-entry of a spacecraft | 1 |

***Sample answer:***

The angle of re-entry is between 5.2 – 7.2 degrees. If the angle of re-entry is too steep, the spacecraft will decelerate too quickly. Heat will not be able to be dissipated quickly, and hence the spacecraft may be destroyed or cause high g-forces to be experienced. To overcome the high g-forces, astronauts are seated in such a way as to ensure blood is not forced away from the brain. In addition, to ensure a safe landing, parachutes are used to slow the spacecraft enough so the impact with the ground is within safe limits. If the angle is too shallow then there is a concern that the spacecraft will be reflected off the atmosphere into space.

### Question 23

| Criteria | Marks |
|---|---|
| • Clearly explains how the current in the wire loop affects the straight conductor, showing a good understanding of the forces associated with the loop and the straight conductor | 3 |
| • Shows some understanding of the forces associated with the sides of the loop and/or the straight conductor | 2 |
| • Shows a basic understanding of a force associated with the loop or the straight conductor | 1 |

***Sample answer:***

Sides *AB* and *CD* are perpendicular to the straight wire and do not contribute any force.

Side *BC* has current in the same direction as the wire and has an attractive force. Side *DA* has current in the opposite direction as the wire and has a repulsive force. As *DA* is further from the straight wire than *BC*, its magnitude is smaller and partly balances the latter.

The overall force is the unbalanced attractive force of side *BC* causing the wire and loop to attract.

### Question 24 (a)

| Criteria | Marks |
|---|---|
| • Shows correct process to calculate the number of turns | 2 |
| • Shows partial substitution into a relevant formula | 1 |

***Sample answer:***

$$\frac{V_{out}}{V_{in}} = \frac{N_{out}}{N_{in}} \text{ so } N_{out} = \frac{V_{out}}{V_{in}} N_{in} = \frac{660000}{23000} \times 2000 = 57391$$

**Question 24 (b)**

| Criteria | Marks |
|---|---|
| • Shows correct process to calculate the power loss | 3 |
| • Correctly substitutes to calculate secondary current<br>OR<br>• Shows partial substitution into relevant formulae | 2 |
| • Shows partial substitution into a relevant formula | 1 |

***Sample answer:***

$$\frac{V_P}{V_S} = \frac{I_S}{I_P} = \frac{n_P}{n_S} \quad , \quad P = I^2 R$$

Using $\frac{V_P}{V_S} = \frac{I_S}{I_P} \quad \frac{23000V}{660000V} = \frac{I_S}{100A}$

$$I_S = \frac{23000 \times 100}{660000} = 3.48A$$

Power loss $= I_S^2 \, R_S$

$= (3.48)^2 \times 2000W$

$= 24 \text{ k}W$

***Answers could include:***

$2.3 \times 10^6 = I^2R + IV$

$= 2000I^2 + 660000I$

$1150 = I^2 + 330I$

$I = 3.5A$

**Question 25 (a)**

| Criteria | Marks |
|---|---|
| • Outlines a suitable investigation | 2 |
| • Shows a basic understanding of an AC induction motor<br>OR<br>• Identifies a feature of a suitable investigation | 1 |

***Sample answer:***

A circular metallic disc was placed near a magnet that could be spun in the same axis. When the magnet was turned the metal disc also started rotating in the same direction.

**Question 25 (b)**

| Criteria | Marks |
|---|---|
| • Clearly explains how the motor effect is used in an AC motor<br>• Relates motion to alternating current | 3 |
| • Shows some understanding of the motor effect and/or the operation of an AC motor | 2 |
| • Identifies a feature of an AC motor<br>OR<br>• Identifies a feature of the motor effect | 1 |

***Sample answer:***

The motor effect is the production of a force on a current-carrying conductor in a magnetic field. In an AC motor the force on the sides of a coil on the rotor produces a torque that causes the coil to rotate. The direction of the torque is maintained in the same sense by the AC applied reversing the current every 180° of the coil's rotation. This keeps the motor rotating due to the torque produced by the motor effect.

**Question 26 (a)**

| Criteria | Marks |
|---|---|
| • Shows correct process to calculate the energy | 2 |
| • Shows partial substitution into a relevant formula | 1 |

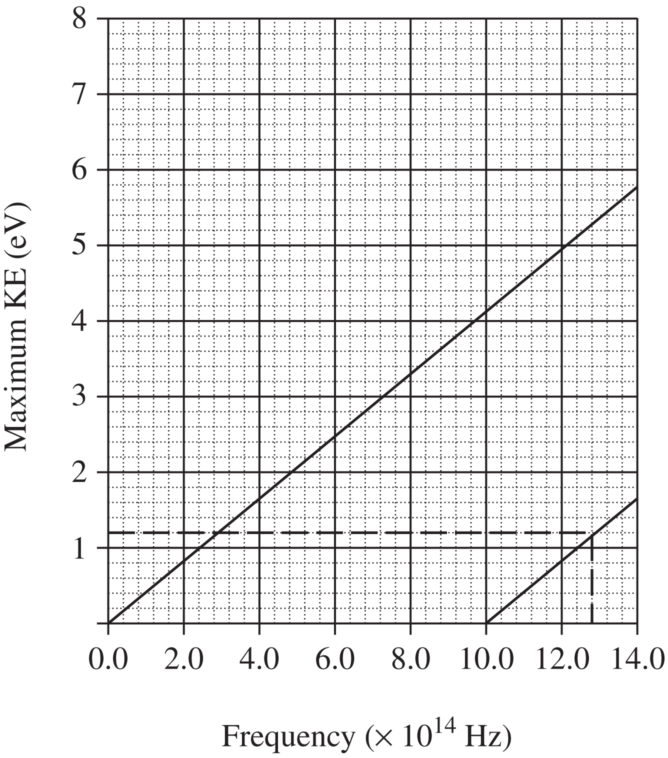
***Sample answer:***

$$c = f\lambda \qquad E = hf = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\,Js\times3\times10^{8}\,ms^{-1}}{415\times10^{-9}\,m} = 4.79\times10^{-19}\,J$$

## Question 26 (b)

| Criteria | Marks |
|---|---|
| • Draws a line on the graph with the correct gradient and intercept<br>• Determines the correct value of frequency | 3 |
| • Draws a line on the graph with one correct feature and shows a valid approach to find a value of frequency using the line<br>OR<br>• Draws a line on the graph with the correct gradient and intercept | 2 |
| • Shows one correct feature on the graph<br>OR<br>• Shows a valid approach to find the value of frequency | 1 |

***Sample answer:***




To find intercept

$$4.1\text{V} = 4.1 \times 1.602 \times 10^{-19} \text{ J of energy required to be supplied by the photon.}$$

$$= 6.56 \times 10^{-19} \text{ J}$$

$$hf = 6.56 \times 10^{-19} \text{ J}$$

$$f = \frac{6.56 \times 10^{-19}}{6.626 \times 10^{-34}}$$

$$= 9.9 \times 10^{14}$$

Gradient = same as Al

From graph maximum KE(eV) = 1.2 eV

Frequency = 12.8 Hz

$= 12.8 \times 10^{14}$ Hz

**Question 27 (a)**

| Criteria | Marks |
|---|---|
| • Clearly explains, using physics principles, why the space probe takes the path | 3 |
| • Identifies reasons<br>OR<br>• Outlines a reason | 2 |
| • Identifies a reason | 1 |

***Sample answer:***

The space probe is placed in orbit above the Earth in a low Earth orbit to limit the size of payload required and flexibility of launching. At the appropriate time rockets fire to take it out of orbit on a path towards a rendezvous with Jupiter. The space probe now takes advantage of the slingshot effect.

**Question 27 (b)**

| Criteria | Marks |
|---|---|
| • Shows correct process to calculate the period | 2 |
| • Shows partial substitution into a relevant formula | 1 |

***Sample answer:***

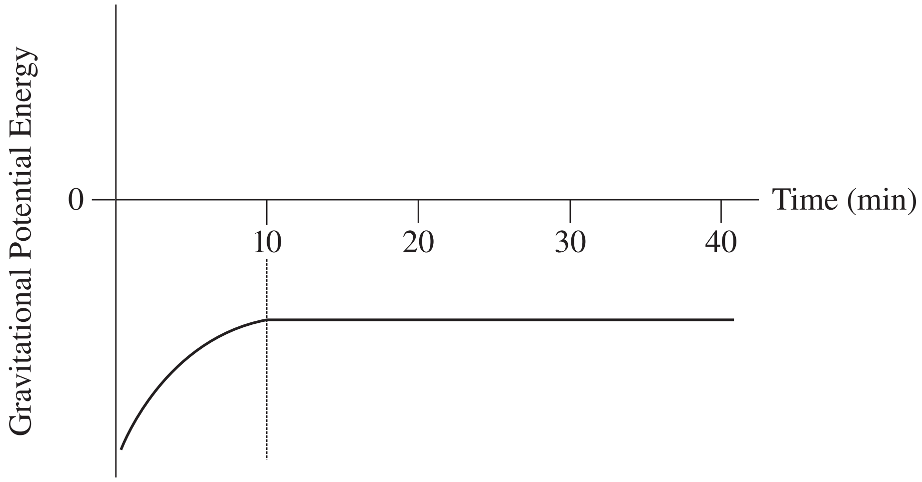
Orbit = 188 km above the surface, hence, R = 6380 km + 188 km = 6568 km

$$\frac{R^3}{T^2} = \frac{GM}{4\pi^2} \text{ hence } T = 2\pi\sqrt{\frac{\left((6380+188)\times 10^3\right)^3}{6.67\times 10^{-11}\times 6\times 10^{24}}} = 5286 \text{ sec} = 88.11 \text{ min}$$

## Question 27 (c)

| Criteria | Marks |
|---|---|
| • Sketches a correct graph | 2 |
| • Sketches a graph with a correct feature | 1 |

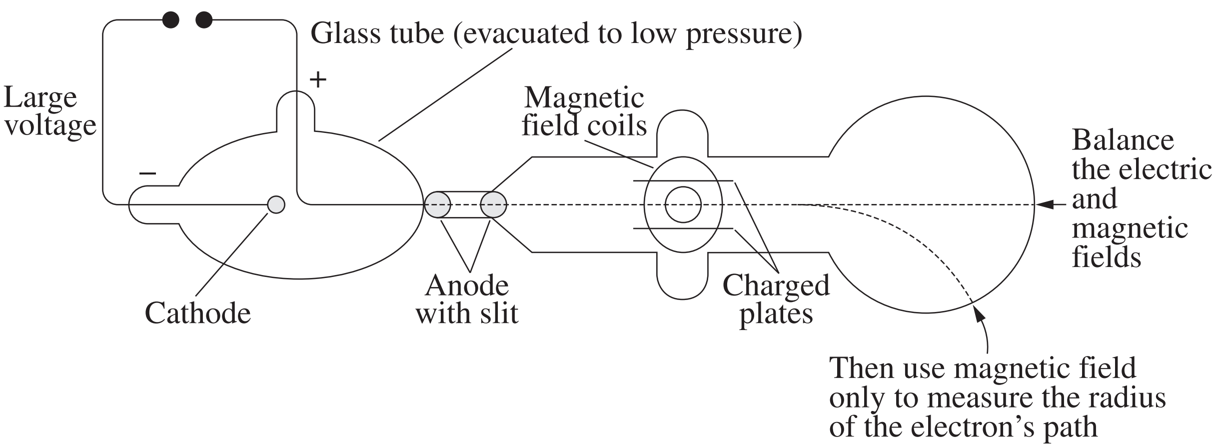
***Sample answer:***



**Question 28 (a)**

| Criteria | Marks |
|---|---|
| • Draws an annotated diagram that clearly shows how Thomson's experiment can be performed | 3 |
| • Draws a diagram that shows some features of Thomson's experiment | 2 |
| • Shows a basic understanding of Thomson's experiment | 1 |

***Sample answer:***




**Question 28 (b)**

| Criteria | Marks |
|---|---|
| • Shows correct process to calculate the radius of the electron's path | 3 |
| • Equates $F = qvB$ and $F = \frac{mv^2}{r}$ to find $r$<br>OR<br>• Shows partial substitution into relevant formulae | 2 |
| • Shows partial substitution into a relevant formula | 1 |

***Sample answer:***

Equating $F = qvb$ and $F = \frac{mv^2}{r}$

$$qvb = \frac{mv^2}{r}$$

$$r = \frac{mv}{qB}$$

$$r = \frac{\left(9.109 \times 10^{-31}\right) \times \left(1 \times 10^{7}\right)}{\left(1.602 \times 10^{-19}\right) \times \left(9 \times 10^{-4}\right)}$$

$$r = 0.063\ m$$

## Question 29

| Criteria | Marks |
|---|---|
| • Shows a thorough understanding of how doping affects the way a current is carried in a semiconductor<br>• Relates the conductivity of semiconductors to energy gaps<br>• Relates the production of a current to the movement of holes and electrons<br>• Differentiates between n and p-type semiconductors in terms of negative charge carriers and positive holes<br>• Shows how negative charge carriers and positive holes contribute to the current in n and p-type semiconductors | 5 |
| • Shows a sound understanding of the link between the conductivity of semiconductors and energy gaps<br>• Shows a sound understanding of the link between current and the movement of holes and electrons<br>• Shows a sound understanding of how currents are carried differently in n and p-type semiconductors | 4 |
| • Shows some understanding of the conductivity of semiconductors<br>• Shows some understanding of the link between current and the movement of holes and electrons<br>• Shows some understanding of different types of semiconductors | 3 |
| • Outlines features of a semiconductor AND/OR doping AND/OR how a current is carried | 2 |
| • Identifies a feature of a semiconductor<br>OR<br>• Identifies a feature of doping<br>OR<br>• Identifies a feature of how a current is carried | 1 |

***Sample answer:***

Undoped semiconductors have limited conductivity with the valence band and conduction bands separated by a small energy gap. Equal numbers of holes and electrons move in opposite directions to make up the current flow. When an electron jumps into the conduction band it leaves a vacancy, a hole, which is then filled by another electron. Electrons will tend to migrate to the positive side and holes to the negative side creating the current.

The conductivity of the semiconductor can be increased by doping, if either Group III or Group V impurity is added to the semiconductor. Group V impurities add an extra electron to the lattice structure forming an n-type semiconductor. These electrons have a smaller energy gap and electrons become the dominant charge carriers.

If a Group III impurity is added a hole is introduced into the lattice structure. Holes are then the dominant charge carriers.

## Question 30 (a)

| Criteria | Marks |
|---|---|
| • Clearly relates the resulting motion of the cannonballs to Galileo's analysis of projectile motion | 3 |
| • Shows some understanding of Galileo's analysis of projectile motion<br>AND/OR<br>• Links an aspect of the motion to Galileo's analysis | 2 |
| • Identifies a feature of Galileo's analysis of projectile motion<br>OR<br>• Shows some understanding of the motion of the cannonballs | 1 |

***Sample answer:***

Galileo used geometry to show that the trajectory of a projectile is a parabola. The shape of the curve generated is parabolic. He also stated that the horizontal and vertical components of velocity were independent of each other. This is clearly shown as the ball drops from the same height and reaches the ground at the same time. Hence it has the same vertical rate in each case whether it has a horizontal component or not. He also showed that the horizontal component (ignoring resistance) is constant. Ball Q travels half the horizontal distance in the first three seconds and half in the next three, which could lead to an understanding of inertia. The ball has no horizontal force acting on it and keeps moving at the same rate.

## Question 30 (b)

| Criteria | Marks |
|---|---|
| • Correctly plots the positions of the balls with correct calculations | 4 |
| • Correctly shows and/or justifies some features of the trajectories | 2–3 |
| • Correctly shows one feature of the flight | 1 |

***Sample answer:***

For ball *P*:

As it falls from the maximum height $u = 0$.

Therefore $y = \frac{1}{2}at^2$

When $T = 1s,\ y = \frac{1}{2}a \quad y = 3$ units so $\frac{1}{2}a = 3$ units

When $T = 2s,\ y = \frac{1}{2}a \times 2^2$ and $\frac{1}{2}a = 3$ unit, $y = 3 \times 4 = 12$ units

When $T = 3s,\ y = \frac{1}{2}a \times 3^2$ and $\frac{1}{2}a = 3$ units, $y = 3 \times 9 = 27$ units

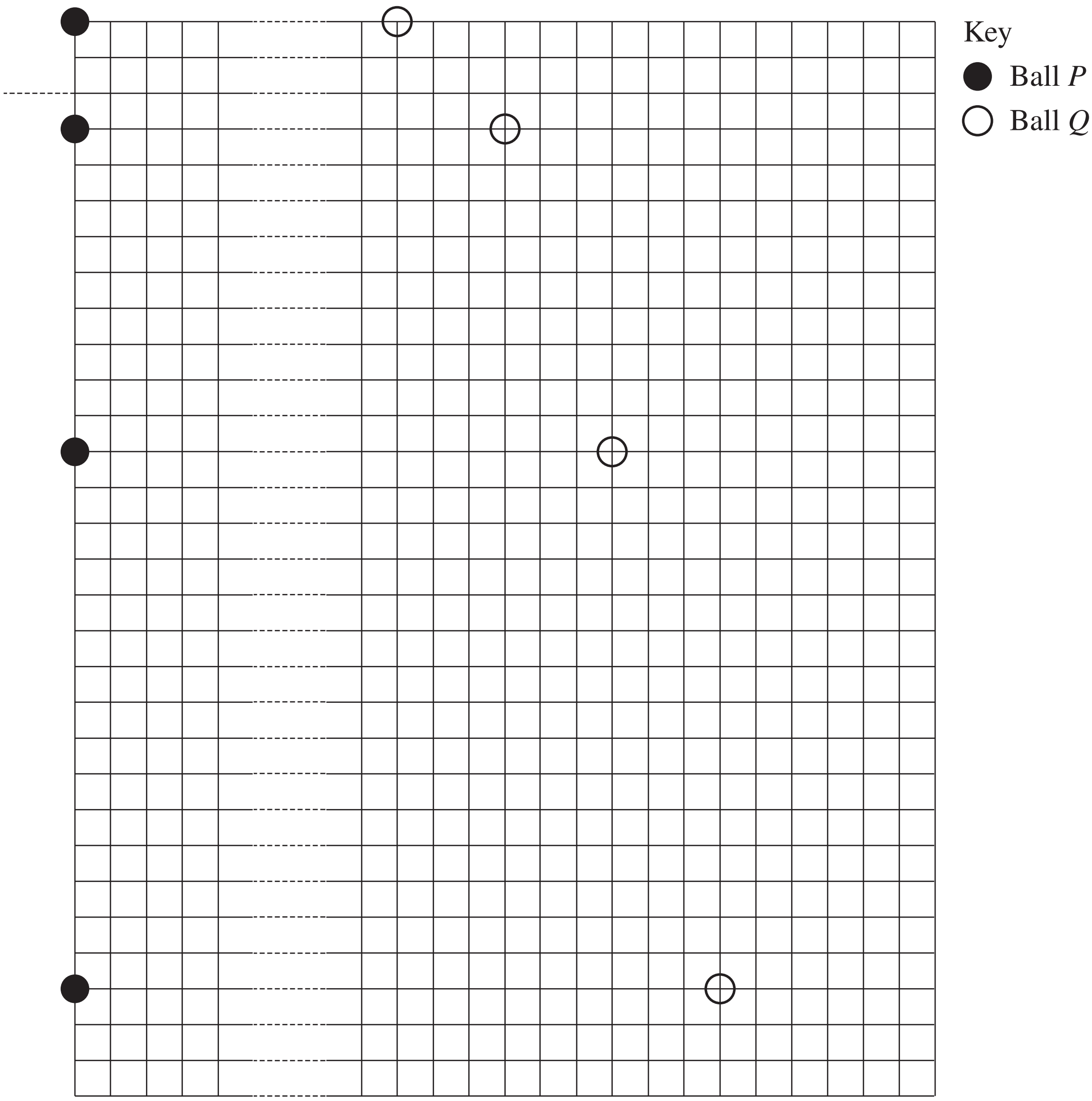
For ball *Q*:

Vertical displacements are the same as ball *P*.

Horizontally the ball keeps travelling 3 units per second at a constant rate.

Question 30 (b)

***Sample answer (continued):***



## Question 31

| Criteria | Marks |
|---|---|
| • Shows a comprehensive understanding of the advantages of AC over DC in electricity supply<br>• Clearly relates the advantages to how the adoption of AC as the dominant electricity supply benefits society<br>• Communicates ideas in an organised manner using appropriate terminology | 6 |
| • Shows a good understanding of the advantages of AC over DC in electricity supply<br>• Links the advantages to how the adoption of AC as the dominant electricity supply benefits society | 5 |
| • Shows a sound understanding of the advantages of AC over DC in electricity supply<br>• Shows some link between the advantages and how the adoption of AC as an electricity supply benefits society | 4 |
| • Shows some understanding of the advantages of AC over DC<br>• Shows some understanding of why/how adopting AC as an electricity supply benefits society<br>OR<br>• Shows a sound understanding of the advantages of AC over DC<br>OR<br>• Shows a sound understanding of why/how adopting AC as an electricity supply benefits society | 3 |
| • Identifies feature(s) of AC and/or feature(s) of DC and/or benefit(s) to society from adopting AC for electricity supply | 2 |
| • Identifies a feature of AC<br>OR<br>• Identifies a feature of DC<br>OR<br>• Identifies a benefit to society from adopting AC for electricity supply | 1 |

***Sample answer:***

AC has many advantages over DC in both production and distribution. AC is easy to convert using transformers to different voltages for different applications. There is less energy loss in high voltage transmissions and hence it can be transmitted over long distances at high voltages and can also be stepped down for usage and safety reasons. This allows power to be generated away from cities and reduces pollution generated in cities. DC cannot be transformed easily so there is a need for DC to be generated close to the source. The cost of DC generation and distribution is higher. Another problem with producing DC is split ring commutators which present problems when running at high speeds. The slip ring commutators of AC are smoother with less arcing. They provide fewer problems and are more reliable. AC allows for the mass production of electricity away from cities and provides a cheap, reliable and flexible power supply which is available throughout much of the modern world today. It has contributed greatly to industrial development creating many goods and services at an affordable price that have allowed our lives to be much easier. Electric refrigerators and washing machines for instance reduce the household chores creating more leisure time. Products such as TV and mobile phones provide information quickly around the world and have contributed to globalisation.

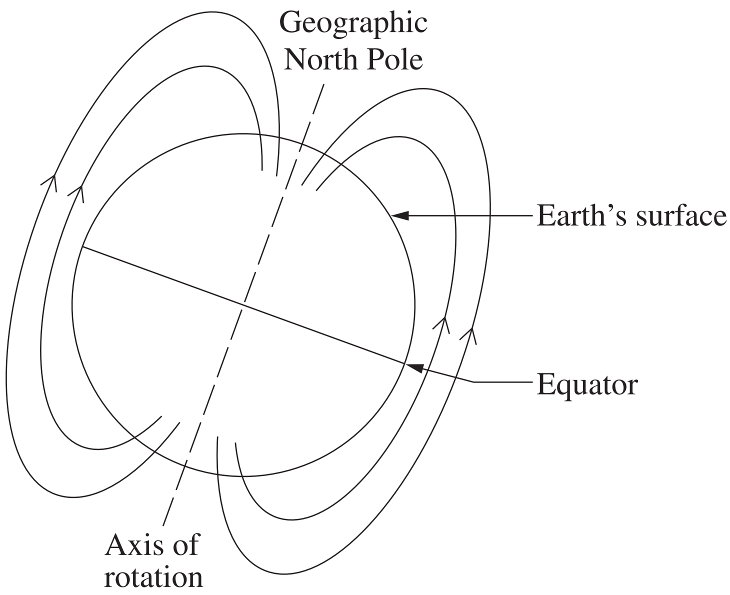
# Section II

## Question 32 – Geophysics

### Question 32 (a) (i)

| Criteria | Marks |
|---|---|
| • Correctly draws a diagram to describe Earth's present magnetic field with appropriate labels | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***



**Question 32 (a) (ii)**

| Criteria | Marks |
|---|---|
| • Identifies formation of rocks on both sides of the boundary<br>• Outlines how parallel magnetic stripes are formed<br>• Links magnetic stripes to sea floor spreading | 3 |
| • Shows some understanding of the formation of rocks on the boundary AND/OR the formation of magnetic stripes | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***

At a diverging plate boundary, basaltic rocks are formed on both sides of the boundary and are overprinted with characteristics of Earth's magnetic field at the time of formation. As more rocks are formed, the older rocks move away from the boundary. If Earth's polarity or magnetic field strength changes, then the magnetic overprint in the younger rocks changes. This leads to a pattern of parallel magnetic stripes. The age of the magnetic anomalies can be used to calculate the rate of sea floor spreading.

**Question 32 (b) (i)**

| Criteria | Marks |
|---|---|
| • Identifies reflection and absorption of wavelengths | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***

If white light strikes a red surface, shorter wavelengths will be absorbed and the observer sees longer wavelengths of the spectrum such as red light reflected.

**Question 32 (b) (ii)**

| Criteria | Marks |
|---|---|
| • Clearly describes how remote sensing can be used to monitor changes in vegetation | 3 |
| • Shows some understanding of how remote sensing can be used to monitor changes | 2 |
| • Identifies a feature of remote sensing<br>OR<br>• Shows a basic understanding of monitoring changes in vegetation | 1 |

***Sample answer:***

Remote sensing is the acquisition of data using remote instrumentation rather than direct measurements. Data acquisition is rapid and numerous, and detailed surveys can be carried out rapidly. Different plant types and different communities give off different radiation spectra and these data can be manipulated spatially, temporally and radiometrically. Changes in vegetation patterns, such as those caused by bushfire or drought, health of vegetation and introduction of new species can be compared during successive surveys and changes monitored.

**Question 32 (c)**

| Criteria | Marks |
|---|---|
| • Shows a thorough understanding of the use of both seismic refraction and reflection techniques in oil and gas exploration<br>• Gives similarities and/or differences between reflection and refraction techniques<br>• Relates these to oil and gas exploration | 4 |
| • Shows a sound understanding of the use of seismic refraction and reflection techniques in oil and gas exploration | 3 |
| • Shows some understanding of seismic refraction AND/OR reflection techniques | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***

All seismic surveys use an energy source to send waves through Earth. These waves are reflected or refracted off the interface caused by rocks with different densities. The waves reach the surface and are detected with geophones. In reflection surveys, the waves are reflected off the interfaces and multichannel seismographs can be used to map several horizons with each shot. Seismic refraction surveys use first arrivals that are refracted along the interfaces and are generally used for shallow targets. Seismic data is used to interpret subsurface geology such as reefs and anticlines.

In oil and gas exploration reservoirs generally have different properties and are shown as anomalies on seismic traces. For example, bright spots may indicate gas accumulations and oil interfaces may show up as flat surfaces.

**Question 32 (d)**

| Criteria | Marks |
|---|---|
| • Shows a thorough understanding of the components of the raw gravity measurements<br>• Clearly explains a range of reasons for data reduction with reference to the diagram and the table | 5 |
| • Shows a sound understanding of the components of the raw gravity measurements<br>• Explains reasons for data reduction with reference to the diagram and/or table | 4 |
| • Outlines reasons for data reduction with reference to the diagram and/or table | 3 |
| • Identifies reasons for data reduction<br>OR<br>• Outlines a reason for data reduction | 2 |
| • Provides some relevant information | 1 |

***Sample answer:***

Raw gravity values above a resource will reflect the nature of the resource including size, shape and density of the component rocks as well as properties of nearby features. Data reduction is the processing of the raw data to remove the components of gravity not related to the resource.

Data reduction is needed for several reasons.

- The gravity stations are at different altitudes and there is a high hill, Mount Noble, close by.
- A free air correction should be made to eliminate decreases in gravity due to distance from the centre of Earth (some points of the survey are at higher altitude).
- An altitude correction should be made to remove increased gravity because of the increased thickness of rock at higher altitude.
- A Bouguer correction should be made to resolve the difference between the expected value and the actual value.
- The differences in probable rock densities have to be taken into account as sandstone is likely to be less dense than granite.

**Question 32 (e)**

| Criteria | Marks |
|---|---|
| • Shows a thorough understanding of geophysical methods and mineral exploration programs<br>• Clearly relates geophysical methods to mineral exploration programs and makes the benefits evident<br>• Communicates ideas in an organised manner using appropriate terminology | 6 |
| • Shows a good understanding of geophysical methods and mineral exploration programs<br>• Links geophysical methods to mineral exploration programs<br>• Provides a description of the benefits | 5 |
| • Shows a sound understanding of geophysical methods and mineral exploration programs<br>• Provides some link between the two<br>• Outlines the benefits | 4 |
| • Shows some understanding of geophysical methods and/or mineral exploration programs<br>• Identifies some benefits or outlines a benefit | 3 |
| • Outlines a geophysical method<br>OR<br>• Identifies features of geophysical methods and/or mineral exploration programs | 2 |
| • Identifies a feature of geophysical methods or mineral exploration programs | 1 |

***Sample answer:***

Geophysics is the analysis of features of Earth using data other than direct measurement. Early mineral exploration programs relied on surface observations of rocks which were compiled into maps from which subsurface features were interpreted. Geophysical methods use the laws of physics to interpret the features of Earth. For example, some mineral deposits have a magnetic signature which shows up as a magnetic anomaly which can be drilled; large or very dense ore bodies have a gravity anomaly; some ores contain radioactive elements which show up as a radiometric anomaly; seismic surveys can be used to determine geological structures, and the shape and depth of basins.

Geophysical surveys can be readily adapted to modern transport methods such as airborne surveys using helicopters. Airborne radiometric and magnetic surveys can cover very large areas and acquire very large amounts of data in a short time. A land gravity survey may take many days whereas the same survey can be carried out using a helicopter in a day. Thus the surveys are cheaper. Remote sensing techniques can be used to rapidly manipulate and process data thus making it cheaper to interpret the data.

Because of the speed at which large volumes of data can be interpreted, larger areas can be covered and more potential targets identified and evaluated for drilling. Less productive targets can be eliminated thus increasing success rates.

## Question 33 — Medical Physics

### Question 33 (a) (i)

| Criteria | Marks |
|---|---|
| • Outlines how ultrasound can be used to determine the flow of blood | 2 |
| • Identifies a feature of ultrasound | 1 |

***Sample answer:***

The use of ultrasound to measure blood flow uses the principle of the Doppler Effect. The movement of the cells within the blood changes the frequency of the reflected ultrasound. The difference in frequency between the transmitted ultrasound frequency and the reflected ultrasound frequency is a measure of the blood flow.

### Question 33 (a) (ii)

| Criteria | Marks |
|---|---|
| • Clearly explains how a two-dimensional image can be constructed using the type of scan | 3 |
| • Shows some understanding of the type of scan and/or how a two-dimensional image can be constructed | 2 |
| • Identifies a feature of the type of scan | 1 |

***Sample answer:***

Multiple scans, at different angles or spacing, are taken of the same area. A computer converts each scan to a B scan then analyses and overlays these B scans to produce a two-dimensional picture.

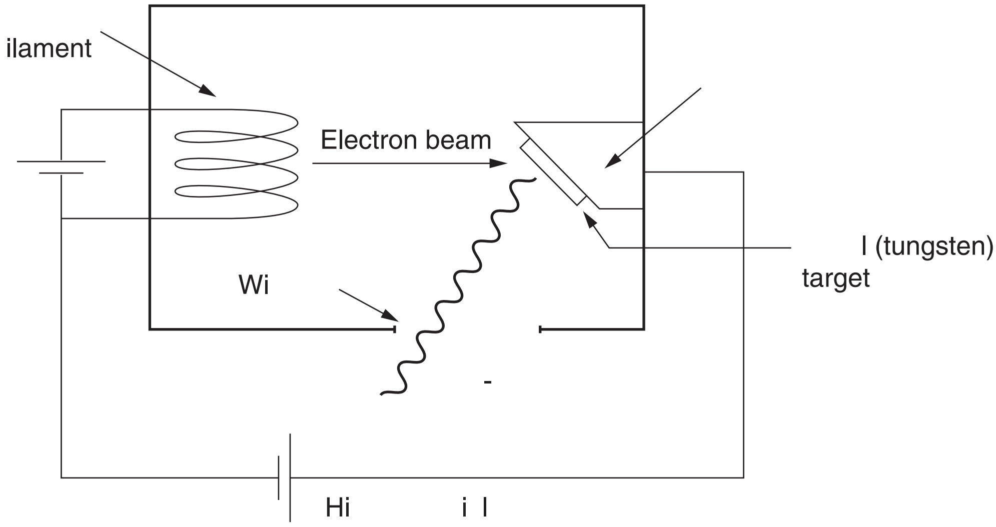
**Question 33 (b) (i)**

| Criteria | Marks |
|---|---|
| • Clearly outlines a method of generating X-ray radiation | 2 |
| • Shows a basic understanding of generating X-ray radiation | 1 |

***Sample answer:***

A heated filament releases electrons that are directed as a beam towards an anode. When the electrons are absorbed some of the energy is converted to X-rays. The anode can be directed so that X-rays are directed toward a window which can be changed to suit the area of the body under investigation.

***Answers could include:***




**Question 33 (b) (ii)**

| Criteria | Marks |
|---|---|
| • Clearly compares the use of a conventional X-ray image to a CT scan in an investigation of the lungs | 3 |
| • Identifies features of X-ray images and/or CT scans | 2 |
| • Identifies a feature of X-ray images or CT scans | 1 |

***Sample answer:***

CT scans have greater resolution than ordinary X-rays as they can produce a three-dimensional image of the interior of the lung. In addition, X-rays require high contrast between body structures which is not the case with lung tissue, so the results may not be of suitable quality for a diagnosis to be made.

**Question 33 (c)**

| Criteria | Marks |
|---|---|
| • Provides a comprehensive description of the physics principles underpinning the use of PET for producing a diagnostic image | 4 |
| • Outlines some characteristics of PET and links these to the use of PET for producing a diagnostic image | 3 |
| • Identifies some characteristics of PET | 2 |
| • Names the diagnostic tool<br>OR<br>• Identifies a characteristic of PET | 1 |

***Sample answer:***

A positron emission tomography (PET) device uses a radioisotope that is deficient in neutrons. During decay radioisotopes such as Carbon-11 protons decay to produce neutrons and positrons. Positrons are positively charged electrons. At the beginning of a procedure a radiopharmaceutical which contains the radioisotope is given to the patient with the radioisotope accumulating in the area of the body under investigation. During the short decay period an emitted positron interacts with an electron where the radiopharmaceutical has accumulated, annihilating each other to produce two gamma rays which are emitted at 180 degrees to each other. These gamma rays are detected by sensors surrounding the body called photomultipliers and converted to an electrical signal. The electrical signal is amplified and applied to a computer which constructs an image based on the location of the gamma ray pairs.

**Question 33 (d)**

| Criteria | Marks |
|---|---|
| • Clearly describes how properties of protons in nuclei are used in MRI production | 5 |
| • Outlines how properties of protons in nuclei are used in MRI production | 4 |
| • Identifies properties of protons in nuclei<br>• Outlines how one of these is used in MRI production | 3 |
| • Identifies properties of protons in nuclei<br>OR<br>• Outlines how a property of protons in nuclei is used in MRI production | 2 |
| • Identifies a property of protons or a feature of MRI | 1 |

***Sample answer:***

Protons in nuclei carry a magnetic spin which can couple to an external field. When protons in nuclei are subjected to a strong uniform external field their two spin orientations align at an angle with the external field, tracing out a conical path centred around the direction of the external field. This process is called precession. The frequency of the precession motion of spins depends on the external field.

A radio frequency (RF) oscillator pulse matching the precession frequency applied to these protons causes aligned spins to flip as well as to precess in step (in phase) with each other, which creates a magnetic field perpendicular to the external field. After the RF pulse some protons flip back to their original state and emit radio waves which can be detected by a radio receiver and processed by a computer to produce an image (MRI).

***Answers could include:***

- Description of image production based on RF receiver input and computer processing
- Description of relationship between RF receiver and the protons
- Description of the r pulse on the protons
- Description of the interaction of the external magnetic field and the protons

## Question 33 (e)

| Criteria | Marks |
|---|---|
| • Makes an informed judgement on the impact of medical applications of physics on society<br>• Shows a thorough understanding of the different types of applications and their effects on society<br>• Clearly relates the positive and negative effects of the applications<br>• Communicates ideas in an organised manner using appropriate terminology | 6 |
| • Shows a good understanding of medical applications of physics<br>• Describes their effects on society | 5 |
| • Shows a sound understanding of medical applications of physics<br>• Outlines their effects on society | 4 |
| • Identifies effects of medical applications of physics on society<br>• Outlines one of these effects | 3 |
| • Identifies effects of medical applications of physics on society<br>OR<br>• Outlines an effect of medical applications of physics on society | 2 |
| • Identifies an effect of medical applications of physics | 1 |

***Sample answer:***

Medical technology has benefited from the wider advances in physics with the invention of X-rays, computer-aided tomography (CAT), magnetic resonance imaging (MRI), ultrasound, radiotherapy and endoscopy for use in medical diagnosis. All of these tools are widely available non-invasive diagnostic procedures.

The use of non-invasive medical technology enables simpler medical procedures to be performed which do not require hospitalisation or surgery to obtain information or can provide diagnostic information where an invasive procedure is not possible eg foetal ultrasound. In addition, the possibility of infection is eliminated in a non-invasive diagnostic investigation. Further, with the widespread availability of non-invasive diagnostic procedures the general health of people has improved, mortality rate has been reduced, life expectancy is longer.

However, this has come at a cost. The costs of medical technology, aged care and the availability of expensive diagnostic investigation have pushed up the price of health beyond what individuals can afford and places great strain on the economic ability of a nation to provide affordable health care to all its citizens.

Advances in non-invasive medical technology and their use can collide with the morals and ethical principles of the society or provide diagnostic information which is beyond safe treatment eg brain tumours or foetal abnormalities. This has the potential to delay or prohibit new technology and treatments from becoming quickly available to the detriment of people who would benefit.

Overall, the advancement of medical technology has been beneficial to society even though the cost is becoming prohibitive.

***Answers could include:***

Effects on society in terms of health outcomes, ethics and economic costs

## Question 34 — Astrophysics

### Question 34 (a) (i)

| Criteria | Marks |
|---|---|
| • Provides an explanation | 2 |
| • Provides a piece of relevant information | 1 |

***Sample answer:***

Star X is a close star. A close star appears to move against the background stars as the viewing location is changed by the motion of the Earth around the Sun. The stars that are further away move very little as they are too far away. This is an effect called solar parallax.

### Question 34 (a) (ii)

| Criteria | Marks |
|---|---|
| • Shows correct process to calculate how much brighter star X would appear | 3 |
| • Shows partial substitution into relevant formulae | 2 |
| • Shows partial substitution into a relevant formula | 1 |

***Sample answer:***

$$M = m - 5\log\left(\frac{2.5}{10}\right)$$

$$M - m = 3.01$$

$$100^{\frac{3.01}{5}} \doteqdot 16$$

Therefore, the star would appear 16 times brighter.

**Question 34 (b) (i)**

| Criteria | Marks |
|---|---|
| • Outlines type of light emitted by a spectral class A star<br>AND<br>• Relates this to the function of blue and red filters | 2 |
| • Shows some understanding of what a filter does OR type of light given off by a spectral class A star | 1 |

***Sample answer:***

The star produces more blue light than red light. It would appear brighter when viewed through a blue filter as a blue filter only lets through blue light. As there is less red light, the red filter would allow less light through and the star would appear to be less bright.

**Question 34 (b) (ii)**

| Criteria | Marks |
|---|---|
| • Clearly relates the use of different coloured filters to measurement and classification | 3 |
| • Shows some understanding of using coloured filters for measurement and/or classification | 2 |
| • Identifies a reason | 1 |

***Sample answer:***

By viewing the light through a blue filter (B) and then using a yellow-green filter (V), the different filters allow a colour index to be measured. This can help to classify the star as it is a quantitative measure of the colour. The brightness of a star can vary depending on the method of measurement. By having a standard set of filters the measurement is standardised.

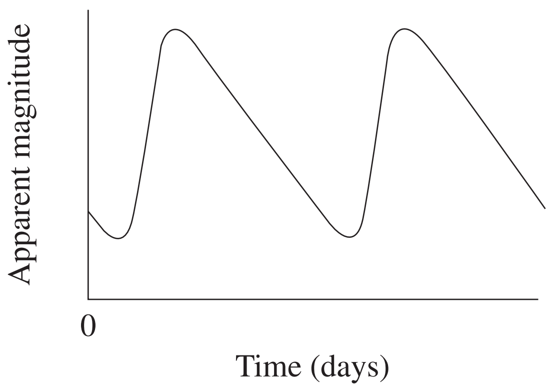
## Question 34 (c)

| Criteria | Marks |
|---|---|
| • Clearly explains two possible reasons | 4 |
| • Provides a clear explanation of one possible reason<br>OR<br>• Identifies two possible reasons and outlines one of them | 3 |
| • Identifies two possible reasons<br>OR<br>• Outlines one possible reason | 2 |
| • Identifies one possible reason | 1 |

***Sample answer:***

The change in brightness could be due to a supernova if the change in brightness is extreme, sudden and temporary. This is due to the rapidly expanding shell.

Another reason could be that the star was a Cepheid variable. If it was a Cepheid, one would expect to observe a distinctive light curve, increases and decreases in intensity, over a period of a few days or weeks as shown below. This is due to the expansion and contraction of the star.



## Question 34 (d)

| Criteria | Marks |
|---|---|
| • Shows a thorough understanding of how the age of stars is determined<br>• Identifies relevant features of the H-R diagram and the spectral lines<br>• Clearly shows how these relate to the evolution of the stars | 5 |
| • Shows a good understanding of how the age of stars is determined<br>• Identifies relevant features of the H-R diagram and the spectral lines | 4 |
| • Shows a sound understanding of how the age of stars is determined<br>• Identifies relevant features of the H-R diagram and/or the spectral lines | 3 |
| • Shows some understanding of the H-R diagram and/or the spectral lines and/or the evolution of stars | 2 |
| • Shows a basic understanding of the H-R diagram, the spectral lines or the evolution of stars | 1 |

***Sample answer:***

In a cluster of stars, it is assumed that all of the stars are the same age as they form together. Stars evolve when they run out of fuel. The brighter stars are larger, the mass luminosity relationship shown provides evidence for this. The larger stars ‘burn’ faster as shown and hence remain on the main sequence for a shorter amount of time. In this cluster, there are no hot blue main sequence stars. The line on the H-R diagram with no dots shows where the larger main sequence stars should have been. This provides evidence for the age of the stars in the cluster as presumably the stars such as the blue stars have evolved into red giants and then white dwarfs. By looking at where the stars turn off the main sequence the age of the star can be predicted. In this cluster the turn off point is for stars of G class or stars similar to our Sun. The Sun is expected to live for about 10 billion years. The cluster is hence about 10 billion years old. The evidence for their evolution can be found in their position on the H-R diagram eg a red giant is brighter than a red main sequence star. As they are the same colour it is assumed they are the same temperature. Looking at the spectra more carefully it can be seen that the spectral lines are narrower indicating that the star itself is less dense than a main sequence star, providing evidence that the star expanded as part of its evolutionary process.

**Question 34 (e)**

| Criteria | Marks |
|---|---|
| • Shows a thorough understanding of the methods of obtaining good quality images of celestial objects using ground-based telescopes<br>• Provides an evaluation of the methods<br>• Clearly shows how the methods positively and/or negatively affect the quality of images<br>• Communicates ideas in an organised manner using appropriate terminology | 6 |
| • Shows a good understanding of the methods of obtaining good quality images of celestial objects using ground-based telescopes<br>• Provides a clear description of the methods<br>• Relates features of these methods to the quality of the images | 5 |
| • Shows a sound understanding of the methods of obtaining good quality images of celestial objects using ground-based telescopes<br>• Outlines some methods<br>• Identifies some effects on these methods on image quality | 4 |
| • Shows some understanding of the methods of obtaining good quality images of celestial objects<br>• Identifies methods and outlines one method | 3 |
| • Identifies methods of obtaining good images of celestial objects<br>OR<br>• Outlines a method of obtaining good images of celestial objects | 2 |
| • Identifies a feature of ground-based telescopes OR a method of obtaining good quality images of celestial objects | 1 |

***Sample answer:***

In order to obtain good quality images various problems need to be overcome. No one method seems to address all of the problems. Problems include: the distortion and absorption of light due to the atmosphere; the distortion of the telescope mirror especially as they get bigger; the difficulty in gathering light from faint objects, the background light due to population centres.

By initially placing the telescope away from population centres and at high altitude the amount of atmosphere the light has to penetrate is reduced, limiting the problem but not eliminating it. The best locations still have limited resolution for optical telescopes. Further techniques such as active optics can be used to straighten the primary mirrors using actuators and a slow feedback system. This is effective and allows for large mirrors for example 10 m mirrors to be used and sharper images and detection of fainter objects to be created, but the change in the mirror is quite slow. Adaptive optics uses a small flexible mirror to sample and correct the starlight collected by the primary mirror. There is a very fast feedback system and it is very successful in correcting atmospheric distortions but some sensitivity is compromised with this technique. These techniques when combined can form very impressive images at a lower cost than space-based telescopes.

***Answers could include:***

Answers may also include discussion of photographic vs ccds or interferometry.

## Question 35 — From Quanta to Quarks

### Question 35 (a) (i)

| Criteria | Marks |
|---|---|
| • Shows correct process to calculate the wavelength of the photon | 2 |
| • Shows partial substitution into a relevant formula | 1 |

***Sample answer:***

Using the Rydberg equation:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

The ground state = final state = $n = 1$ and the initial state = $n = 3$.

Applying the formula, the wavelength of the emitted photon is 102.7 nm.

### Question 35 (a) (ii)

| Criteria | Marks |
|---|---|
| • Provides a clear explanation using de Broglie's hypothesis | 3 |
| • Shows some understanding of de Broglie's hypothesis and/or why the photon is not absorbed | 2 |
| • Identifies a reason<br>OR<br>• Shows a basic understanding of de Broglie's hypothesis | 1 |

***Sample answer:***

The de Broglie hypothesis is based on the notion that stationary states are analogous to standing waves. Each stationary state will relate to a particular wavelength and each standing wave will be an integer multiple of the ground state wavelength. This can be mathematically described by the quantisation of angular momentum based on de Broglie's wave-particle duality theory ($\lambda = h/mv$ and hence $mvr = h/2\pi$).

Bohr postulated that electrons could only exist in defined stationary states and that electrons could only transition from one state to another if the initial energy allowed the electron to occupy a state that was a multiple of the ground state wavelength.

### Question 35 (b) (i)

| Criteria | Marks |
|---|---|
| • Clearly outlines why gravitational forces are irrelevant in the nucleus | 2 |
| • Shows a basic understanding of gravitational forces or the forces associated with the nucleus of an atom | 1 |

***Sample answer:***

Newton's Law of Universal Gravitation states that there is a force of attraction between all types of matter, including particles in the nucleus. However, this force is overwhelmingly weak compared to the electrostatic forces between protons. Yet the nucleus remains stable instead of forcing the particles apart. Given the disproportionate nature of the two forces, there must be another, much stronger force involved in ensuring the stability of the nucleus.

### Question 35 (b) (ii)

| Criteria | Marks |
|---|---|
| • Clearly explains how energy may be released in a nuclear reaction with reference to the diagram | 3 |
| • Shows some understanding of binding energy and/or mass defect and/or fusion and/or fission | 2 |
| • Shows a basic understanding of the energy associated with nuclear reaction | 1 |

***Sample answer:***

The binding energy of a nucleon is a measure of the strength of the bond between a nuclear force and the nucleus. For a typical nucleus the binding energy is equivalent to the mass defect by the formula $E = mc^2$. For elements below iron (Fe) the joining together of atoms produces nuclei with higher binding energy per nucleon producing energy. This is called nuclear fusion. For elements larger than Iron, which are split into two new smaller nuclei, the binding energy per nucleon is greater than the average binding energy, again releasing energy. This is called nuclear fission.

## Question 35 (c)

| Criteria | Marks |
|---|---|
| • Clearly describes the use of the neutron as a probe<br>• Relates the applications to the properties of neutrons | 4 |
| • Shows a good understanding of the properties of neutrons and the use of the neutron as a probe | 3 |
| • Shows some understanding of the properties of neutrons and/or the use of the neutron as a probe | 2 |
| • Identifies a property of neutrons or an application of the neutron as a probe | 1 |

***Sample answer:***

The neutron is a nucleon with a similar mass to the proton. Unlike the proton the neutron has no charge. Hence it is not affected by magnetic or electric field and will not be deflected by the protons in the nucleus allowing the neutron to penetrate dense materials, such as aircraft engines and weld joints. Any interaction with the nucleus, where the neutron is absorbed, is likely to make the nucleus unstable producing isotopes of the element which can be studied for additional properties.

The neutron has properties that are associated with quantum physics. The neutron has a de Broglie wavelength allowing it to interact with materials at the atomic level. This is useful when studying the properties of semiconductors in the production of integrated circuits. If the wavelength is comparable with the inter-atomic lattice spacing then an interference pattern will result which can be analysed. This is useful in the study of biological substances or inorganic substances such as pharmaceuticals.

Slow thermal neutrons produced in a nuclear reactor have energy that is similar to the energy of atomic vibrations in solids and liquids and hence are useful in analysing other properties of atoms. Slow thermal neutrons are also used in a controlled fission reaction. These neutrons interact with a uranium nucleus, splitting the uranium atom, to produce two smaller atoms plus an additional 3 neutrons plus energy.

**Question 35 (d)**

| Criteria | Marks |
|---|---|
| • Clearly describes the significance of the Manhattan Project to society<br>• Shows a thorough understanding of nuclear reactors and the positive and negative aspects of nuclear physics | 5 |
| • Shows a good understanding of nuclear physics<br>• Provides some degree of reflection on the significance of the project in relation to the positive and/or negative aspects of nuclear physics | 4 |
| • Shows a sound understanding of nuclear physics and the impacts of nuclear physics on society | 3 |
| • Shows some understanding of nuclear physics | 2 |
| • Shows a basic understanding of the Manhattan Project | 1 |

***Sample answer:***

The Manhattan Project was a top-secret nuclear bomb project. Two different types of nuclear bombs and nuclear fission reactors, including the Fermi reactor, were developed as part of this project. The first use of atomic bombs on Hiroshima and Nagasaki clearly showed the destructive power of such a weapon and hastened the end of World War II. The fear of this weapon led to the nuclear arms race between the USA and the Soviet Union. After the Soviet Union had proved their nuclear capability in 1949, tension between the two nations increased and continued through to the 1990s. Many other nations also developed nuclear weapons. Even after nuclear weapons reduction programs, there are still large stockpiles of weapons, which makes the possibility of nuclear attack a reality for society. Nuclear reactor development has led to the development of nuclear power plants, which has provided a carbon dioxide free power source for society, currently supplying much of Europe’s energy. There have been, however, nuclear accidents such as Fukushima, which have had devastating effects: death, disease and rendering regions uninhabitable. Nuclear power plants can also produce radioactive isotopes which have been used to benefit society in medicine, agriculture and industry. In medicine, radiotherapy is used to target cancer and radioactive tracers can be used to test organ function.

**Question 35 (e)**

| Criteria | Marks |
|---|---|
| • Makes an informed judgement of the effectiveness of the Bohr–Rutherford model in accounting for experimental observations<br>• Shows a thorough understanding of the features and associated theories of the Bohr–Rutherford model<br>• Clearly relates the strengths and limitations in accounting for experimental observations to the features and associated theories<br>• Communicates ideas in an organised manner using appropriate terminology | 6 |
| • Shows a good understanding of the features and associated theories of the Bohr–Rutherford model<br>• Clearly shows how these could be applied to account for experimental observations<br>• Identifies strengths and limitations of the applications | 5 |
| • Shows a sound understanding of the features and associated theories of the Bohr–Rutherford model<br>• Shows how these could be applied to account for experimental observations<br>• Identifies strength(s) and/or limitation(s) of the applications | 4 |
| • Shows some understanding of how the Bohr–Rutherford model could be applied to account for experimental observations | 3 |
| • Identifies feature(s) and/or associated theory/theories of the Bohr–Rutherford model | 2 |
| • Identifies a feature or an associated theory of the Bohr–Rutherford model | 1 |

***Sample answer:***

The Bohr model has a central nucleus surrounded by an orbiting electron, as described by Rutherford. This model predicted that the electron would collapse into the nucleus due to the attraction force between the electron and other protons.

Bohr proposed that electrons existed in stationary states and these states were quantised according to de Broglie’s wave-particle duality theory, Planck’s quantised energy theory and Pauli’s exclusion principle which limited the number of electrons that could be in any stationary state. This ensured that the atom remained stable.

The model was supported by data in relation to the spectral lines of hydrogen that had previously been observed by Balmer.

Bohr’s model, while effective in describing the hydrogen atom, had limitations when applied to other experimental evidence associated with hydrogen atoms. The model was unable to explain the different relative intensities of spectral lines of hydrogen nor could it explain the effect of magnetic fields as described by Zeeman, now known as the Zeeman Effect.

The model did not work when applied to the spectral lines of larger atoms, although had some validity for helium. The implication of this was that a new model of the atom was required, one that would be dependent on quantum physics and not the classical model of Bohr and Rutherford.

## Question 36 — The Age of Silicon

### Question 36 (a) (i)

| Criteria | Marks |
|---|---|
| • Constructs a substantially correct truth table | 2 |
| • Shows some understanding of truth table construction<br>• Correctly identifies one row of the truth table | 1 |

***Sample answer:***

| A | B | S | C |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |

### Question 36 (a) (ii)

| Criteria | Marks |
|---|---|
| • Identifies properties of input and output transducers<br>• Relates properties of a thermistor to the properties identified above to explain why a thermistor can be considered both an input and an output transducer | 3 |
| • Identifies properties of input transducers AND/OR output transducers AND/OR thermistors | 2 |
| • Identifies a property of a transducer OR a thermistor | 1 |

***Sample answer:***

An input transducer converts a feature of the environment into an electrical parameter while an output transducer converts an electrical parameter into a feature of the environment. A thermistor is a resistor that changes its electrical resistance depending on its temperature and is an input transducer. When connected to voltage or current source, the thermistor acts as a resistor and heats up, affecting its environment and hence is an output transducer.

## Question 36 (b) (i)

| Criteria | Marks |
|---|---|
| • Correctly states the purpose of the 1.5 kΩ and the left 12 kΩ resistors<br>• Correctly states the purpose of the right 12 kΩ and the 18 kΩ resistors | 2 |
| • Correctly states a purpose of the resistors OR<br>• Identifies connections of X as an inverting amplifier OR<br>• Identifies Y as a switch | 1 |

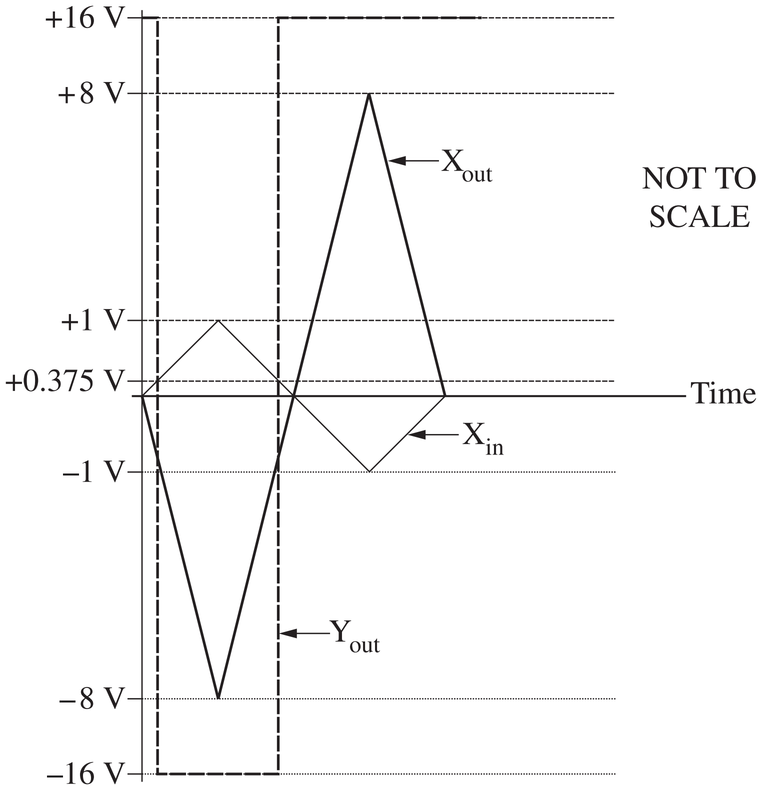
***Sample answer:***

The 1.5kΩ and the left 12kΩ resistors are the input and feedback resistors of an inverting amplifier.
The right 12kΩ and the 18kΩ resistors are connected as a voltage divider.
.

## Question 36 (b) (ii)

| Criteria | Marks |
|---|---|
| • Draws correct $X_{out}$ and $Y_{out}$ waveforms | 3 |
| • Draws correct $X_{out}$ or $Y_{out}$ waveform OR<br>• Provides some features of the $X_{out}$ and $Y_{out}$ waveforms | 2 |
| • Indicates one feature of the $X_{out}$ or $Y_{out}$ waveforms | 1 |

***Sample answer:***



### Question 36 (c)

| Criteria | Marks |
|---|---|
| • Outlines similarities and differences between transistors and ICs | 4 |
| • Outlines similarities or differences between transistors and ICs<br>OR<br>• Outlines a similarity and a difference between transistors and ICs | 3 |
| • Identifies similarities or differences between transistors and ICs<br>OR<br>• Identifies a similarity and a difference between transistors and ICs | 2 |
| • Identifies a feature of a transistor or an IC | 1 |

***Sample answer:***

ICs and transistors are both mass-produced by etching/diffusion methods on silicon chips. ICs contain many transistors usually with other components on a single chip. Transistors have three connections but ICs usually have many more. Transistors are still individually used for high power or simple circuits whereas ICs are used for low power or complex circuits. Both require cooling arrangements and/or protective circuitry to prevent thermal damage.

### Question 36 (d)

| Criteria | Marks |
|---|---|
| • Shows a thorough understanding of LEDs and traditional forms of illumination<br>• Clearly justifies the use of LEDs over traditional forms of illumination in everyday situations | 5 |
| • Shows a sound understanding of LEDs and traditional forms of illumination<br>• Provides some justification in relation to the use of LEDs over traditional forms of illumination | 4 |
| • Shows some understanding of LEDs and traditional forms of illumination<br>• Identifies an advantage of LEDs over traditional forms of illumination | 3 |
| • Identifies features of LEDs and/or traditional forms of illumination | 2 |
| • Identifies a feature of LEDs or traditional forms of illumination | 1 |

***Sample answer:***

While a modern LED produces a single frequency colour at any operating current with little heat loss, traditional forms of illumination such as an incandescent lamp have a maximum colour that is current dependent and loses considerable energy as heat loss. Modern LEDs are available in all spectrum colours while incandescent lamps need to be filtered to achieve a single colour, greatly increasing energy loss.

Originally the low light output of LEDs limited their use to small displays only, but modern ones can now be used for general illumination with high efficiency and long lifetimes compared to incandescent lamps. They can be used to form TV screens etc owing to their very fast response, but against this are their relatively higher cost and restricted temperature and operating conditions compared to other types of lighting.

**Question 36 (e)**

| Criteria | Marks |
|---|---|
| • Shows a comprehensive understanding of the development of the silicon chip and the features of electronics that have been influenced by the development<br>• Clearly relates the development of electronics to the features of the silicon chip<br>• Communicates ideas in an organised manner using appropriate terminology | 6 |
| • Shows a good understanding of the development of the silicon chip and the features of electronics that have been influenced by the development<br>• Shows some link between the development of electronics and the features of the silicon chip | 5 |
| • Shows a sound understanding of the features of electronics that have been influenced by the development of the silicon chip<br>• Links the above to feature(s) of the silicon chip | 4 |
| • Shows some understanding of the features of electronics that have been influenced by the development of the silicon chip<br>• Links the above to a feature of the silicon chip | 3 |
| • Identifies some features of the silicon chip and/or electronics that have been influenced by the development of the silicon chip | 2 |
| • Identifies a feature of the silicon chip<br>OR<br>• Identifies a feature of electronics that has been influenced by the development of the silicon chip | 1 |

***Sample answer:***

Silicon chip technology allows semiconductor devices to be made on a single crystal layer of silicon. The ability to 'print' thousands of circuit elements rather than individual small diodes and transistors has significantly reduced the size and cost of electronic devices. Since switching is much quicker, owing to the close proximity of relevant components both within and between silicon chips, speed and memory have greatly increased with decreasing power consumption. The combining of once separate integrated circuits into single chips that perform different functions has facilitated the development of complex and multi-function devices. This has enabled equipment such as telephones and computers to become lightweight, compact and portable, and allowed the real-time capture and processing of audio and video images, and gaming and television capabilities.

The silicon chip has revolutionised the development of electronics and enabled complex processors and circuitry to be incorporated into everyday home appliances.

As the size and speed of circuit elements has now approached a limiting atomic level, further developments in performance will come from development of multiple or parallel processing within silicon chips.

# Physics

## 2014 HSC Examination Mapping Grid

**Section I**
**Part A**

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 1 | 1 | 9.2.2.2.6 | H6 |
| 2 | 1 | 9.3.3.2.1 | H7, H8 |
| 3 | 1 | 9.1.12.4a, 9.1.12.2b, 9.2.1.3.1 | H12 |
| 4 | 1 | 9.4.3.2.5 | H3 |
| 5 | 1 | 9.3.3.3.4 | H7 |
| 6 | 1 | 9.2.1.2.3, 9.2.2.2.10 | H6, H9 |
| 7 | 1 | 9.3.2.2.4, 9.3.2.3.2 | H9 |
| 8 | 1 | 9.3.4.2.4, 9.3.4.3.1 | H7, H9 |
| 9 | 1 | 9.4.4.2.4 | H7 |
| 10 | 1 | 9.3.2.2.4, 9.3.2.3.2 | H9 |
| 11 | 1 | 9.4.2.2.5, 9.4.2.2.3 | H7, H10 |
| 12 | 1 | 9.3.1.2.5, 9.3.1.3.5 | H6, H9 |
| 13 | 1 | 9.3.1.3.5 | H3 |
| 14 | 1 | 9.3.2.3.1 | H9 |
| 15 | 1 | 9.2.3.3.2 | H9 |
| 16 | 1 | 9.4.2.2.2 | H10 |
| 17 | 1 | 9.4.1.2.7, 9.4.1.3.3 | H6, H9 |
| 18 | 1 | 9.4.1.2.3, 9.4.1.2.8 | H9 |
| 19 | 1 | 9.2.4.2.9, 9.2.4.3.5 | H6 |
| 20 | 1 | 9.2.2.3.1 | H6 |

**Section I**
**Part B**

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 21 | 3 | 9.4.4.2.7 | H5 |
| 22 | 3 | 9.2.2.1.3, 9.2.2.2.12 | H1, H7 |
| 23 | 3 | 9.3.1.2.2 | H9 |
| 24 (a) | 2 | 9.3.4.3.2 | H7, H9 |
| 24 (b) | 3 | 9.3.4.2.4, 9.3.4.3.2 | H7 |
| 25 (a) | 2 | 9.3.5.3.1 | H9, H11 |
| 25 (b) | 3 | 9.3.5.2.1 | H9 |
| 26 (a) | 2 | 9.4.2.3.4 | H10 |
| 26 (b) | 3 | 9.4.2.2.6, 9.4.2.2.5, 9.4.2.3.4 | H7, H10 |
| 27 (a) | 3 | 9.2.3.2.4 | H6 |

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| 27 (b) | 2 | 9.2.2.3.5 | H6 |
| 27 (c) | 2 | 9.2.1.2.3 | H7, H9 |
| 28 (a) | 3 | 9.4.1.2.8 | H2, H9, H13 |
| 28 (b) | 3 | 9.2.2.3.4, 9.4.1.3.3 | H9 |
| 29 | 5 | 9.4.3.2.6, 9.4.3.3.1, 9.4.3.2.7 | H7, H9 |
| 30 (a) | 3 | 9.2.2.2.2 | H1, H2 |
| 30 (b) | 4 | 9.2.2.3.1 | H9, H6 |
| 31 | 6 | 9.3.3.3.2, 9.3.3.2.5 | H3, H4 |

**Section II**

| Question | Marks | Content | Syllabus outcomes |
|---|---|---|---|
| **Question 32** | | **Geophysics** | |
| 32 (a) (i) | 2 | 9.5.4.2.1 | H9 |
| 32 (a) (ii) | 3 | 9.5.4.2.3, 9.5.4.3.2 | H9 |
| 32 (b) (i) | 2 | 9.5.2.2.1, 9.5.2.3.1 | H10 |
| 32 (b) (ii) | 3 | 9.5.2.2.2 | H10 |
| 32 (c) | 4 | 9.5.3.2.6, 9.5.3.2.7 | H8 |
| 32 (d) | 5 | 9.5.2.2.7, 9.5.2.2.8 | H8, H10 |
| 32 (e) | 6 | 9.5.5.2.1, 9.5.2.2.9 | H1, H3 |
| **Question 33** | | **Medical Physics** | |
| 33 (a) (i) | 2 | 9.6.1.2.8 | H8 |
| 33 (a) (ii) | 3 | 9.6.1.2.7 | H7 |
| 33 (b) (i) | 2 | 9.6.2.2.1 | H17, H10 |
| 33 (b) (ii) | 3 | 9.6.2.2.4 | H10 |
| 33 (c) | 4 | 9.6.3.2.5, 9.6.3.2.3, 9.6.3.2.4 | H3, H10 |
| 33 (d) | 5 | 9.6.4.2.5, 9.6.4.2.2, 9.6.4.2.4, 9.6.4.3.3 | H9 |
| 33 (e) | 6 | 9.6.4.3.5 | H4, H9 |
| **Question 34** | | **Astrophysics** | |
| 34 (a) (i) | 2 | 9.7.4.3.2 | H8 |
| 34 (a) (ii) | 3 | 9.7.4.2.4 | H8 |
| 34 (b) (i) | 2 | 9.7.2.2.2 | H6 |
| 34 (b) (ii) | 3 | 9.7.4.2.1, 9.7.4.3.1 | H8 |
| 34 (c) | 4 | 9.7.5.2.4, 9.7.3.2.3, 9.7.3.2.5, 9.7.5.2.1 | H8 |
| 34 (d) | 5 | 9.7.6.2.5, 9.7.6.2.2, 9.7.3.2.5 | H2, H8 |
| 34 (e) | 6 | 9.7.1.2.5, 9.7.1.2.4, 9.7.4.2.5 | H3 |

| **Question 35** | | **From Quanta to Quarks** | |
|---|---|---|---|
| 35 (a) (i) | 2 | 9.8.1.3.3 | H8, H10 |
| 35 (a) (ii) | 3 | 9.8.2.2.4 | H10 |
| 35 (b) (i) | 2 | 9.8.3.2.7 | H6, H1, H3 |
| 35 (b) (ii) | 3 | 9.8.3.2.9, 9.8.3.3.2 | H7, H10 |
| 35 (c) | 4 | 9.8.4.2.3 | H4, H10 |
| 35 (d) | 5 | 9.8.3.2.10, 9.8.4.3.1 | H4, H10 |
| 35 (e) | 6 | 9.8.1.2.2, 9.8.1.2.3, 9.8.1.2.1, 9.8.2.2.4, 9.8.1.2.6, 9.8.1.3.4 | H10 |
| **Question 36** | | **The Age of Silicon** | |
| 36 (a) (i) | 2 | 9.9.5.3.1 | H6 |
| 36 (a) (ii) | 3 | 9.9.3.2.4, 9.9.3.2.5 | H8 |
| 36 (b) (i) | 2 | 9.9.6.2.2, 9.9.2.2.5 | H9 |
| 36 (b) (ii) | 3 | 9.9.6.2.2, 9.9.2.2.5 | H3 |
| 36 (c) | 4 | 9.9.1.2.4 | H3 |
| 36 (d) | 5 | 9.9.4.3.3 | H3, H4, H10 |
| 36 (e) | 6 | 9.9.1.2.3, 9.9.1.3.1, 9.9.7.2.1, 9.9.1.2.2 | H3 |